AFRL-SA-WP-SR-2013-0001

Viper NHEXS Program

(**N**eck **H**ealth & **EX**ercise **S**trategies)

A Viper Pilot Neck Health & Conditioning Guide

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November 2012

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
7 Nov 2012	Special Report	October 2012 – November 2012

4. TITLE AND SUBTITLE

Viper NHEXS Program: A Viper Pilot Neck Health & Conditioning Guide

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Sean Sarsfield, Reginald O'Hara, Bruce A. Wright

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USAF School of Aerospace Medicine
Aeromedical Research Department/FHC
2510 Fifth St.
Wright-Patterson AFB, OH 45433-7913

8. PERFORMING ORGANIZATION REPORT NUMBER

AFRL-SA-WP-SR-2013-0001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2013-0089, 10 Jan 2013

13. SUPPLEMENTARY NOTES

14. ABSTRACT

High-G flight maneuvers may pose a significant hazard to the neck muscles and surrounding support structures. Therefore, the purpose of this training manual is to provide F-16 pilots with guidance on neck injury prevention strategies and specific neck strengthening exercises. The information contained within this manual is not intended to improve or diagnose neck or spinal injuries. Rather, it is intended to provide general and preventative neck strengthening and stretching strategies. If physical symptoms of significant neck injury are present, seek medical guidance prior to following any of the neck strengthening or stretching exercise strategies recommended in this manual.

15. SUBJECT TERMS

Neck injury, conditioning, strengthening exercises, F-16 pilots

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Reginald O'Hara
U	U	U	SAR	14	19b. TELEPHONE NUMBER *(include area code)*


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56th FIGHTER WING

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Purpose & Intent

High-G flight maneuvers may pose a significant hazard to the neck muscles and surrounding support structures. Therefore, the purpose of this training manual is to provide F-16 pilots with guidance on neck injury prevention strategies and specific neck strengthening exercises. The information contained within this manual is not intended to improve or diagnose neck or spinal injuries. Rather, it is intended to provide general and preventative neck strengthening and stretching strategies. If physical symptoms of significant neck injury are present, seek medical guidance prior to following any of the neck strengthening or stretching exercise strategies recommended in this manual.

The Neck vs. Gs Problem

At least one acute neck pain episode is reported to occur in an estimated 85% of all pilots flying high-performance fighter type aircraft, with the yearly prevalence of neck-related pain for all pilots at 56% [1]. Vandebeek reported over 50% of fighter pilots surveyed stated they had some type of acute neck injury in the preceding 3-month period [2]. Repeated G loads of 4 Gs, considered minimal threshold, can cause disk protrusions, ligamentous injuries, and cervical muscle strains [3]. However, Wagstaff and colleagues [3] reported that 72% of fighter pilots experience neck pain in relation to flying, while 35% experience some low back pain. The reported average G level for acute incidents of in-flight pain was 6.7 G [3]. The three key risk factors contributing to cervical $+G_z$ injuries in fighter pilots include (1) repeated exposure to $+G_z$ forces above $+4G_z$, (2) non-neutral positioning of the head during $+G_z$ maneuvers, and (3) unpreparedness for high +G maneuvers [1].

The F-16 flight performance often doubles that minimum threshold of $+4G_z$. The head weighs 4-5 kg, with the helmet and mask assembly weighing an additional 1.8- 2.2 kg; the static load increases significantly when flying above $+1G_z$; and a pilot's neck can be required to withstand $+G_z$ forces of up to nine times that of gravity [4]. While human neck structures are capable of sustaining axial loads of up to 91 kg, the abrupt G loading encountered in defensive or offensive maneuvers frequently applies significant loads to the cervical spine in an other than axial direction. In a neutral posture, the neck structures are optimally positioned to endure the G_z load. However, once the head is displaced in a direction outside of neutral, the moment arm produces high forces within the neck structures. Therefore, to more adequately prepare pilots for more challenging flying, additional supervised neck resistance exercises outside of the aircraft could be of benefit, especially for those pilots engaged in more high-performance flying [1].

A force can be thought of as a push or pull acting on a body. Each force is characterized by its particular direction and point of application to a given body. The action of force causes the body's mass to accelerate (e.g., F=ma). It's important to know that the overall effect of many forces acting on a system, such as the neck during high G_z load, is a function of the net force, which is the vector sum of all the acting forces (e.g., force derived from the composition of two or more forces) [5]. For example, the "check-six" position while under G stress produces the highest net force within the cervical region because it requires maximal neck rotation. This movement requires maximal recruitment of the neck skeletal muscle motor units, which include the contralateral sternocleidomastoid, levator scapulae, scalenus, splenius capitis, and ipsilateral splenius capitis [6]. Neck forces increase by a factor of 15 when the neck is in a rotated position while under G. The short-brimmed hat configuration of the current helmet-mounted cueing

system requires the pilot to place the neck at an even more extreme angle while in the check-six position to maintain visual contact with an adversary. Some researchers note that the F-16 presents a high-risk environment for G-related neck pain due to its angled back rest and its agility [3,7]. Rotation of the neck as a lead in to a pain event was nearly universal in the outcomes. The 30° inclined position of the F-16 seat causes the pilot to flex the neck forward (e.g., chin toward chest) and away from the support of the headrest during maneuvers. Additionally, there is a decreased likelihood of using cockpit structures to brace the helmet against while under G. All factors may result in neck pain and injury for the fighter pilot.

Most researchers have been unable to determine if there is a relationship between subject's anatomy and risk of neck injury. However, there is a reduced risk of injury for those pilots who perform specific neck strengthening exercises and utilize cockpit structures for bracing during high-G maneuvers. Albano and colleagues reported that for every 100 flying hours in the F-16, the risk of neck injury increased by 6.9% [8]. Other contributing factors for neck injury are age, flight hours, G load, G onset rate, duration of exposure, duration of rest between exposures, and number of repeated exposures [3,7].

Neck injuries can range from minor muscle strains (most common) to vertebral fractures, vertebral disc injury, and nerve damage, which may require surgery. Other common related injuries may include skeletal muscle/connective tissue micro-trauma injury, excessive lengthening of nerve roots and irritation to surrounding cervical tissues caused by shearing and compressive forces on the intervertebral discs, connective tissue tears, support structure degeneration, vertebral fractures, and nerve tissue damage. The mechanisms contributing to more severe injuries may include, but are not limited to, multiple soft tissue traumas that can result in weakening of cervical support structures [6]. Notable physical symptoms may include numbness/tingling, noticeable muscle weakness, and sharp and/or severe pain in the cervical region.

Preflight Strategies

Neck Strengthening

The two primary preflight warm-ups include isolation neck muscle strength and cervical range of motion (ROM) exercises. Although neck muscle strength has been investigated by several experts in the field, their results regarding its effectiveness in preventing neck strain remain inconclusive. Nonetheless, most researchers suggest that specificity and intensity of neck strength training offer some degree of neck protection encountered during high-G maneuvers [6]. In fact, good neck and muscle strength and endurance may act more as a preventative measure against perceived neck discomfort post flight [7]. It is recommended that a neck muscle strengthening and endurance program be performed three times weekly for 6 months, coupled with 5% to 10% bi-weekly workload progression based on the subject's adaptations. It's suggested that pilots perform four sets of 10 repetitions per neck strengthening exercise [7]. Nonetheless, the program should ultimately be tailored based on individual adaptation and be supervised [7]. This type of progression may result in reduced risk of neck injuries [1,6,7]. Additionally, there may be a relationship between neck size and strength in providing some protective benefit to supporting cervical structures while under G stress, ultimately resulting in reduced muscle strains and injury to the neck region. A multitude of skeletal muscles cross the neck, allowing for increased ROM (Figure 1).

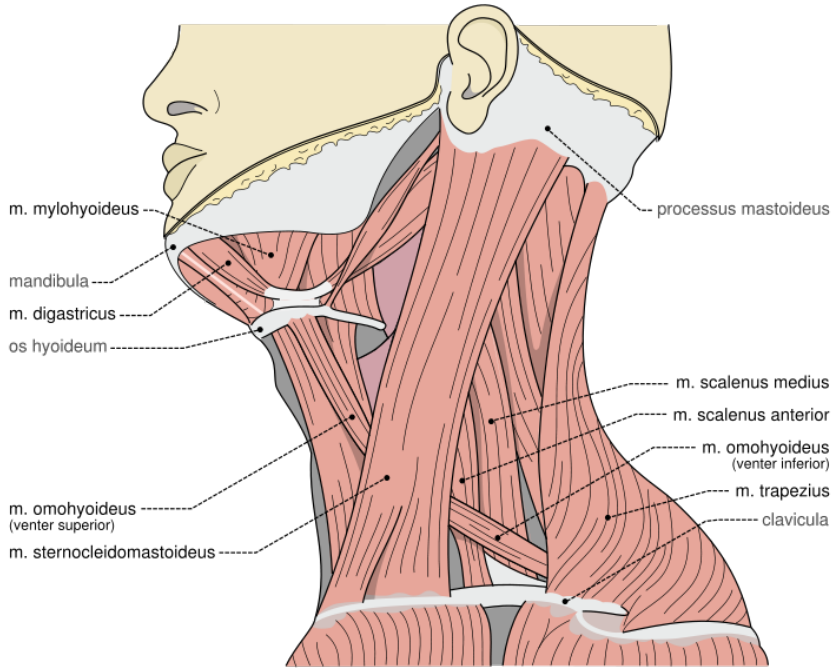

Figure 1. Skeletal Muscles in the Neck

The fundamental movements of the spinal column are flexion, extension, lateral flexion, and rotation. The greatest amount of movement takes place in the cervical and lumbar regions due to the position of the ribcage in the thorax region. In the neck region, the major muscle groups are the sternocleidomastoid, the scalene, and deep prevertebrals. Additionally, the muscles that make up the prevertebrals are responsible for flexing and rotating the spine. The scalene muscles have a unique function because they not only laterally flex the neck, but during forced respiration, they elevate the first three ribs, allowing for lung expansion [9]. The primary muscles involved in flexion (chin to chest) and extension (chin up) of the neck are considered the strongest, followed by the muscles involved in lateral movement of the neck (e.g., bending ear to shoulder); the muscles involved in neck rotation (e.g., looking side to side) are the weakest. Most in-flight maneuvers may force the neck into positions that require a combination of neck rotation, extension, and lateral bending (e.g., check-six). The combination of movements places the neck and its supporting tissues in a position that may cause neck strain (shear stress). Training the neck musculature can be difficult based on the hard and soft tissue structures of the neck muscles and their various movement patterns. Additionally, it can be very difficult to isolate the weakest link in the neck muscles' chain (e.g., muscles responsible for neck rotation).

Popular forms of neck strengthening options could include:

1. The 4-way neck machine. This machine is acceptable for training the muscles responsible for flexing and extending the neck. The 4-way neck machine targets the neck muscles from various angles. However, it does not include a movement to train the muscles responsible for rotating the neck.
2. The neck harnesses allows for more natural movement patterns compared to the 4-way neck machine. However, when using the neck harness, you must exercise caution

by using proper exercise form, since this is a free-weight training device. Without incorporating proper neck-lifting mechanics when using the neck harness, you are more prone to neck injury. Nonetheless, the neck harness allows you to strengthen the neck from various positions to include frontal flexion, left and right lateral flexion, and extension.

3. Exercise bands or towel-work can be awkward to perform and places limitations on the types of neck movements that can be performed. Using a towel to strengthen your neck will allow you to perform movements such as the chin lift and isometric forehead press that target the muscles located on the front of your neck. Nonetheless, performing towel neck strengthening exercises can be awkward, and workload progression is difficult to manipulate.
4. A novel neck strengthening device, called the Halo, has been reported to outperform many other neck strengthening devices primarily because it targets the neck muscles through the entire 360° ROM with a scalable weight load; in addition, it targets the neck muscles responsible for lateral flexion and extension.

Neck strengthening using the Halo is recommended, 3 to 5 minutes daily, using horizontal rotary resistance. Because rotation of the neck is cited as a key lead-in to an acute pain event, the rotary movement is warranted when training the neck musculature. A detailed routine describing this training device can be found on pages 6-7 of this training guide.

Performing 5 to 10 minutes of stretching exercises for the neck and thoracic spine region coupled with various ROM exercises may provide some protective benefit [8]. However, this isn't a universal finding [5]. Normal ROM of the neck may be sufficient for high-G flight, and proper neck strengthening exercises will likely contribute to increased ROM. Nonetheless, ROM about the neck musculature can be reduced due to the aging process. Neck ROM generally deteriorates by an estimated 4° per decade after age 30 [6,10].

A recommended preflight neck warm-up with some ROM work may provide some protection during high-G maneuvers. Because higher demands are placed on the cervical and thoracic spine while flying high-performance aircraft, the neck muscles are significantly strained during flight; therefore, a preflight neck warm-up may ameliorate some of the neck strain incurred during high-G maneuvers. Any type of physical training regimen/workout should be preceded by an active warm-up to help prepare skeletal muscle for higher intensity work. Hence, the muscles of the neck should not be treated differently. The active warm-up does not have to be extensive and should take between 5 to 8 minutes to complete during preflight operations or while traveling to the military operating area.

ROM Preflight Warm-Up

For each of the preflight warm-ups, move through the plane of motion (e.g., flexion, extension, lateral flexion) at least 5 to10 times. Avoid deliberately forcing through a ROM, especially if you experience any unusual musculoskeletal pain (as with a hand pressing helmet) beyond what you can achieve simply moving through natural ROMs.

1. Side to side bending (ear to shoulder)
2. Flexion & extension (chin to chest, chin up)
3. Rotation (look side to side)
4. Rotation + extension to both sides (check-six) and lateral bending

In-Flight Strategies

Some researchers suggest significant neck injury rate differences between F-16 pilots who habitually anchor their body position and place their helmet against the seat prior to G onset and those who do not [11]. Additional differences have been found between those who deliberately unload G to properly reposition as opposed to repositioning while under high G [12]. These findings are consistent with broader conclusions that movement of the neck while under G (especially multiplaner movements like going from a check-six position over the left shoulder to over the right shoulder while under high G) is highly hazardous to the neck.

A suggested in-flight strategy is to use the cockpit structure to support the helmet while under G and to achieve that helmet placement prior to G onset. It is unrealistic to not move the head while under G.

However, any effort to unload and reposition could result in reduction on the cumulative wear and tear on the neck. Additionally, when movement under G is required, minimize concurrent movement in multiple planes of motion (i.e., rotation and flexion). In contract, focus on movement in one plane of motion at a time. For example, when recovering from the check-six position, laterally flex the neck and then rotate.

Postflight Strategies

A postflight neck battle damage check is advisable. Early recognition of significant neck/spine injuries is crucial to positive final outcomes. Surveys of fighter pilots have found rest, heat/cold therapy, sleep, massage, and nonsteroidal anti-inflammatory drugs (i.e., Advil) to be beneficial for minor neck injury recovery and for minor symptom relief. Some anecdotal claims support chiropractic and acupuncture treatments for symptom relief. Nonetheless, there apparently is limited research-based data to support these modalities.

For severe neck injury cases, surgical intervention is an option. An estimated 90% of fighter pilots who require a single level diskectomy or fusion can obtain a waiver for continued service. However, any surgery involving two vertebral levels is permanently disqualifying. However, proper preflight and in-flight strategies will minimize the requirement for aggressive symptom relief and/or surgical intervention.

Neck Strength Conditioning Guide

Purpose & Intent

The goal of this neck strength conditioning guide is to increase the size and force production capability of the neck muscles responsible for neck flexion, extension, and rotation. The neck musculature has the ability to withstand continual low intensity work, as it can support your head for many hours without fatiguing [7]. Training of the neck musculature should follow the general strength and conditioning principles of specificity, volume, overload, and progression. It must be noted that for most people, these muscles are not accustomed to significant overloading (especially the muscles involved with rotation). Therefore, it is prudent to begin with very light loads and progress conservatively with training loads and volumes. Once significant gains are achieved, workloads should still remain fairly low. For example, unlike squats, which require recruitment of very large skeletal muscle groups, neck muscle

strength training requires recruitment of long, thin, and fairly delicate muscles that are not accustomed to daily physical training or overload. Therefore, when starting this neck strengthening program, proceed with caution and ensure your program is supervised by a trained professional.

If significant neck pain or problems already exist, seek the guidance of a flight surgeon prior to commencing any neck training. The 56 TRS physiologist will offer training sessions on an as-needed basis for 56 OG aircrew. Call x-7157 to arrange a time. The movements and techniques for this program are quite unique, and some simple instruction is required.

Neck Strength Training Overview

It is recommended to train the neck muscle groups three to four times a week for a minimum of 10 minutes or 4 x 10 repetitions [7]. This neck training session can be added to any preexisting exercise training routine. This particular neck training program relies exclusively on the Halo training system. Begin with very light resistance (e.g., focus on first increasing repetitions vs. weight) and progress based on your physiological adaptations (e.g., 10% bi-weekly workload increase). For example, start with a 1-kg load, progressing to 2 kg and then to 4 kg over time [7]. Monitor your progress by keeping and maintaining records based on your load, repetitions, and subjective levels of pain and/or progression.

Warm-Up

Ensure the cable attachment point is 1 inch below Halo level. Ensure the bottom of the Halo aligns where a pair of glasses would sit above your ears. Inflate the Halo to achieve a comfortable but secure fit. Use of the chin strap is optional. However, it does improve the security of the Halo.

With minimal resistance & deliberate full range of motion movements:

LLLR = look left, rook right with a stationary torso
QT = quarter turn

1. LLLR facing front, side, back, side
2. Locked neck, spin in place 5 spins each direction
3. Figure 8 facing front and back
4. 10 quicker LLLR at each QT
5. Slow spin in place with 10 LLLRs
6. 1 minute rest prior to continuing

Halo Neck Strengthening Workout

1. LLLR with QT
   a. Start by facing the cable attachment point. While keeping torso stationary, move cranium directly left and right with slow, deliberate, full range of motion movements.
   b. 12 reps each QT.

2. The Spin: Spin in place with neck stationary, 6 turns each direction.
3. The Spin with LLLR: Complete 6 revolutions each direction while completing 6 LLLRs.
4. Figure 8s
    a. Draw an infinity symbol with your nose.
    b. 12 reps facing cable, 12 facing away from cable.
5. Quick Rep LLLR with QT
    a. 12 quick LLLR reps at each QT.
    b. Keep torso rigid, as you will tend to involve more body movement as the neck muscles fatigue.
6. 2-minute rest
7. Locked Neck Body Turns
    a. Add additional resistance.
    b. With locked neck, rotate upper body 90° at each QT while in the athletic stance.
    c. 12 reps each QT.
8. Check-Six
    a. Drop resistance to load from steps 1-5.
    b. Facing attachment point, look down toward left shoulder then high above right shoulder for 12 reps. Reverse to look low right/high left.
    c. For side positions only do low (shoulder close to attachment) to high.
    d. Repeat facing away.
9. Locked Neck Body Turns:
    a. Increase resistance over step 7.
    b. With locked neck, rotate torso through 90° from athletic stance.
    c. 12 reps each QT.
10. Slow LLLRs (advanced only; only after 6-9 weeks of training): Using max weight, do 12 reps LLLR at each QT.

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